of its maximal value.* This agrees with the fact that down to a diameter of 500 $\mu\mu$ the velocity still appears to be independent of size and shape.

It may be well, in conclusion, to emphasise the significance of the experiments. They seem to prove either that the coefficient of sliding friction between two phases is independent of the Laplacian pressure at the interface, or that the range of the molecular attraction is much less than Rücker's estimate—50 $\mu\mu$.

[P.S., *added July* 30.—During the present hot weather, when the water in the laboratory stands at 28° C., the film was found to have diminished in tenacity to a great extent. In order to give it the same degree of fixity under electrical stresses which it possessed at temperatures between 15° and 20°, it had to be thickened with oil until a blue film was produced, which almost entirely stopped the movements of camphor.]

The Origin of Osmotic Effects. IV.—*Note on the Differential Septa in Plants with reference to the Translocation of Nutritive Materials.*

By Henry E. Armstrong, F.R.S., and E. Frankland Armstrong.

(Received and read June 29, 1911.)

Our communication to the Society which was read on June 2 last year† was made under the primary title attached to the present communication, because it appeared to us that many of the osmotic phenomena in plants were to be correlated with effects produced initially by the class of substances to which we have ventured to extend the term *Hormone*, introduced by Starling but applied by him only to certain members of the group. The observations recorded were made with leaves of *Prunus laurocerasus*. In a

* The integral for the pressure at the surface of a sphere in a vacuum is given by Rayleigh ('Phil. Mag.,' 1890 [2], vol. 30, p. 456), as $2\pi\int_0^{2r} f^2\pi(f)\,df - \frac{\pi}{f}\int_0^{2r} f^3\pi(f)\,df$. Putting $\pi(f) = \frac{K}{\beta}e^{-\beta f}$, this reduces to $\frac{\pi K}{\beta^2}\left[e^{-2r\beta}\left(4\frac{r}{\beta}+8\frac{1}{\beta^2}+6\frac{1}{r\beta^3}\right)-6\frac{1}{r\beta^3}+4\frac{1}{\beta^2}\right]$.

† "The Origin of Osmotic Effects. III.—The Function of Hormones in Stimulating Enzymic Change in Relation to Narcosis and the Phenomena of Degenerative and Regenerative Change in Living Structures," 'Roy. Soc. Proc.,' B, 1910, vol. 82.

more recent communication,* in which we have discussed observations made later in the year with leaves of *Aucuba japonica* and a number of other plants, we again called attention to the osmotic effects conditioned by hormones and the suggestion was advanced that the translocation of nutritive materials takes place periodically.

Taken in conjunction with those made by Adrian Brown, our observations show that the outer differential septa in plants are permeable only by substances of a particular type—apparently only by substances having but slight affinity for water; consequently, if the argument apply to plant cells generally, ordinary nutritive materials, such as the sugars, for example, cannot pass through unless the septa are in some measure broken down. It almost stands to reason that the translocation of carbohydrates and many other materials must take place periodically: that at some times the cell walls must be permeable whilst at others impermeable. As we have already pointed out, Darwin's work on insectivorous plants appears to be full of evidence that such is the case.

It is abundantly clear from the behaviour of *Saxifraga sarmentosa*, for example, that the cells generally are lined with a septum which is differentially permeable. When placed in a solution of greater osmotic tension than that within the cells, the coloured fluid is retracted in the well-known way; this effect is easily reversed and the change may be brought about time after time provided that the membrane enclosing the cell contents remain uninjured. The effect cannot be produced after exposure to chloroform and there are many other substances which act similarly; it is therefore to be supposed that it is conditioned by the differential permeability of the thin protoplasmic membrane which lines the cell.

In the account of our experiments with leaves of *Prunus laurocerasus* we stated that, of the three substances into which the glucoside characteristic of the plant, prulaurasin, is resolved—glucose, benzaldehyde and hydrogen cyanide—the last two act as hormones, each being capable of conditioning hydrolysis. In studying the action of these and other hormones, as was to be expected would be the case, significant differences have been brought to light; we propose to make these differences the subject of careful study. On the present occasion we desire to call attention to the special effect produced by hydrogen cyanide, as this appears to us to raise issues of peculiar and wide significance.

If kept in water, leaves such as those of *Prunus laurocerasus* or of *Aucuba japonica* not only remain unchanged during many days but nothing diffuses

* "The Function of Hormones in Regulating Metabolism," 'Annals of Botany,' 1911, vol. 25, pp. 507—519.

out into the liquid; if a substance which can penetrate into the leaf be added to the water, as a rule, not only does the leaf change in appearance but substances soon pass out from it into the surrounding liquid. In the case of *Aucuba*, for example, an amount of reducing sugar equal to from 3 to 4 per cent. on the original weight of the leaf diffuses out into the solution in the course of three or four days.

If the hormone used be hydrogen cyanide, however, although changes take place within the leaf, no reducing sugar passes out into the solution. It suffices to use a solution containing only 0·2 per cent. of the cyanide. The difference has been noticed in the case of a considerable variety of leaves, in roots such as that of the radish and beet, in unripe fruits (cherry and currant) and in unripe seed pods.

Most leaves become coloured more or less distinctly brown, some even black, on exposure in water saturated with either chloroform or toluene; but in a solution of hydrogen cyanide the colour change is far less marked, the green colour being preserved often during a considerable period. The difference is particularly noticeable in the case of leaves which blacken in chloroform, such as those of *Vicia faba*, for example. The almost black colour assumed by the *Aucuba* leaf in presence of chloroform is evidently due to several superposed effects; in the cyanide solution such leaves become highly coloured but not nearly to the same extent as when they are exposed to the action of other hormones.

These differences would seem to be proof that differential septa which break down under the influence of most hormones remain intact when hydrogen cyanide is used, though hydrolytic changes take place within the leaf under the influence of this latter agent.*

Taking into account the manner in which leaves change in appearance when exposed in water saturated with a substance such as toluene, there can be little doubt that the coloration is at least mainly an oxidation effect; and bearing in mind what is known of the effect hydrogen cyanide has in inhibiting oxidation, it appears probable that differential septa remain intact because the "oxidase effect" is eliminated in presence of hydrogen cyanide.

It is well known that oxidation processes are at a maximum in plants during the period when light is inactive and that growth takes place chiefly during this period: the translocation of nutritive materials which necessarily sets in during this period may well take place because the septa are broken

* We have already called attention in our previous communication to the production of reducing sugars within the laurel leaf when it is exposed to the action of hydrogen cyanide.

down and rendered permeable by oxidation; they may be repaired subsequently, when assimilatory processes become ascendant.

We are extending our observations to animal tissues.

We have to thank Mr. Mummery for the assistance he has rendered to us in carrying out a number of the experiments.

The Properties of Colloidal Systems. III.—*The Osmotic Pressure of Electrolytically Dissociated Colloids.*

By W. M. Bayliss, F.R.S., Institute of Physiology, University College, London.

(Received June 30, 1911.)

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In a previous paper* I showed that the osmotic pressure of solutions of Congo red, as measured directly in an osmometer with a membrane of parchment-paper, is about 90—95 per cent. of that which they should have if the dye were present as undissociated single molecules, such as those of glucose or urea. Attention was chiefly directed, in the paper referred to, to the fact that a body behaving as a colloid gives as high an osmotic pressure as if it existed in solution as single molecules and not as aggregates. It is to be remembered, however, that Congo red is the sodium salt of a fairly strong acid and as such must be dissociated to a considerable degree in solutions of the concentration employed. On this account, the interpretation of the experimental results required further work. Subsequent investigations have shown that there are many difficulties in the way of a satisfactory explanation.

* 'Roy. Soc. Proc.,' 1909, B, vol. 81, p. 269.